GROUNDWATER AMBIENT MONITORING AND ASSESSMENT (GAMA)

DOMESTIC WELL PROJECT
GROUNDWATER QUALITY DATA REPORT
YUBA COUNTY FOCUS AREA

CALIFORNIA

Water Boards

STATE WATER RESOURCES CONTROL BOARD

REGIONAL WATER QUALITY CONTROL BOARDS

California State Water Resources Control Board
Groundwater Protection Section
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The GAMA Program staff and management thank all of the volunteer well owners and cooperating county and state agencies that participated in the Yuba County Domestic Well Project.

ABBREVIATIONS AND ACRONYMS

CDPH	California Department of Public Health
DWR	California Department of Water Resources
EC	Electrical Conductivity
GAMA	Groundwater Ambient Monitoring and Assessment
LLNL	Lawrence Livermore National Laboratory
MCL	Maximum Contaminant Level
NL	Notification Level
SMCL	Secondary Maximum Contaminant Level
SWRCB	State Water Resources Control Board
TDS	Total Dissolved Solids
VOCs	Volatile Organic Compounds
µg/L	Micrograms per Liter
mg/L	Milligrams per Liter

ABSTRACT

The State Water Resources Control Board (State Water Board) established the Groundwater Ambient Monitoring and Assessment (GAMA) Program in 2000. Private domestic wells in Tulare County were sampled in 2006 as part of the GAMA Domestic Well Project. Yuba County was selected for sampling due to the large number of domestic wells located within the county and the availability of well-owner data. A total of 181 wells were sampled by Water Board staff, primarily in the valley and foothill areas of the county.

Groundwater samples were analyzed by an accredited environmental laboratory for commonly observed chemical constituents such as bacteria (total and fecal coliform), inorganic parameters (metals, major anions and general minerals), and volatile organic compounds (VOCs). Test results were compared against three public drinking water standards established by the California Department of Public Health (CDPH): primary maximum contaminant levels (MCLs), secondary maximum contaminant levels (SMCLs), and notification levels (NLs). These water quality standards are used for comparison purposes only, since private domestic well water quality is not regulated by the State of California. A total of twenty-two constituents were detected at concentrations above public drinking water standards. Fourteen constituents were detected above a primary MCL, five constituents were above an SMCL, and three were above NLs.

The fourteen constituents were detected above MCLs included total and fecal coliform bacteria, arsenic, beryllium, chromium, nickel, nitrate, nitrite, perchlorate, thallium, 1,2-dibromo-3-chloropropane (DBCP), gross alpha activity, combined radium activity, and uranium activity. Nitrate was the most frequently detected chemical above an MCL, and was detected in 75 wells at concentrations greater than or equal to the MCL of 10 mg/L (nitrate as N). Total coliform bacteria were present in 60 wells, and fecal coliform bacteria were present in 13 wells. DBCP and thallium were detected at concentrations above the MCL in eight and six wells, respectively. All other constituents detected above an MCL were observed in three or fewer wells.

The five chemicals were detected at concentrations above SMCLs, including aluminum, iron, manganese, total dissolved solids (TDS), and zinc. The chemicals detected above an SMCL were all observed in four or fewer wells. Three chemicals were detected above NLs: boron, vanadium, and 1,2,3-trichloropropane. Vanadium was detected in 14 wells at concentrations greater than the NL of 50 µg/L. 1,2,3-trichloroproane and boron were detected above the NL in a single well each.

INTRODUCTION

More than 95 percent of Californians get their drinking water from a public or municipal source - these supplies are typically treated to ensure that the water is safe to drink. However, private domestic wells supply drinking water to approximately 1.6 million Californians. Those served by public or municipal supplies should be concerned about groundwater quality too, as groundwater supplies part or all of the water delivered to approximately 15 million municipal public water supply users. Contaminated groundwater results in treatment costs, well closures, and new well construction which increases costs for consumers.

Groundwater is also an important source of irrigation and industrial supply water. Reliance upon this resource is expected to increase in the future, in part due to increased agricultural and industrial demand, drought, climate change, and population/land-use changes. Consequently, there are growing concerns regarding groundwater quality in California, and whether decreases in quality will affect the availability of this resource. Since the 1980s, over 8,000 public groundwater drinking water sources have been shut down – some due to the detection of chemicals such as nitrate, arsenic, or methyl tert-butyl ether (MTBE).

The State Water Board created the Groundwater Ambient Monitoring and Assessment (GAMA) Program to address public concerns over groundwater quality. The primary objectives of the GAMA Program are to improve comprehensive statewide groundwater monitoring and to increase the public availability of groundwater quality information. The data gathered by GAMA highlight regional and local groundwater quality concerns, and may be used to evaluate whether there are specific chemicals of concern in specific areas throughout the state. The GAMA Program consists of four current projects:

- **Domestic Well Project**: A voluntary groundwater monitoring project that provides water quality information to private (domestic) well owners. To date, the Domestic Well Project has sampled over 1,000 private domestic wells in five county focus areas: Yuba (2002), El Dorado (2003-2004), Tehama (2005), Tulare (2006), and San Diego (2008-2009). State Water Board staff sample the participants' well at no cost to the well owner.

- **Priority Basin Project**: A comprehensive, statewide groundwater monitoring program that primarily uses public groundwater supply wells in high-use, or "priority," groundwater basins. These high-use basins contain more than 95% of all public groundwater supply wells. As of April 2009, the Priority Basin Project has sampled over 1,700 wells in over 90 different groundwater basins. The United States Geological Survey (USGS) is the project technical lead, with support from LLNL.

- **Special Studies Project**: Focuses on identification of contaminant sources and assessing the effects of remediation in private domestic and public supply wells. The Special Studies Project also studies aquifer storage and recovery projects. LLNL is the project technical lead.

- **GeoTracker GAMA**: A publicly-accessible, map-based on-line query tool that helps users find useful groundwater quality data and information.

This Data Summary Report summarizes Domestic Well Project results from 181 domestic wells sampled in the Tulare County Focus Area collected during 2006. Sampled well locations are shown in Figure 1.

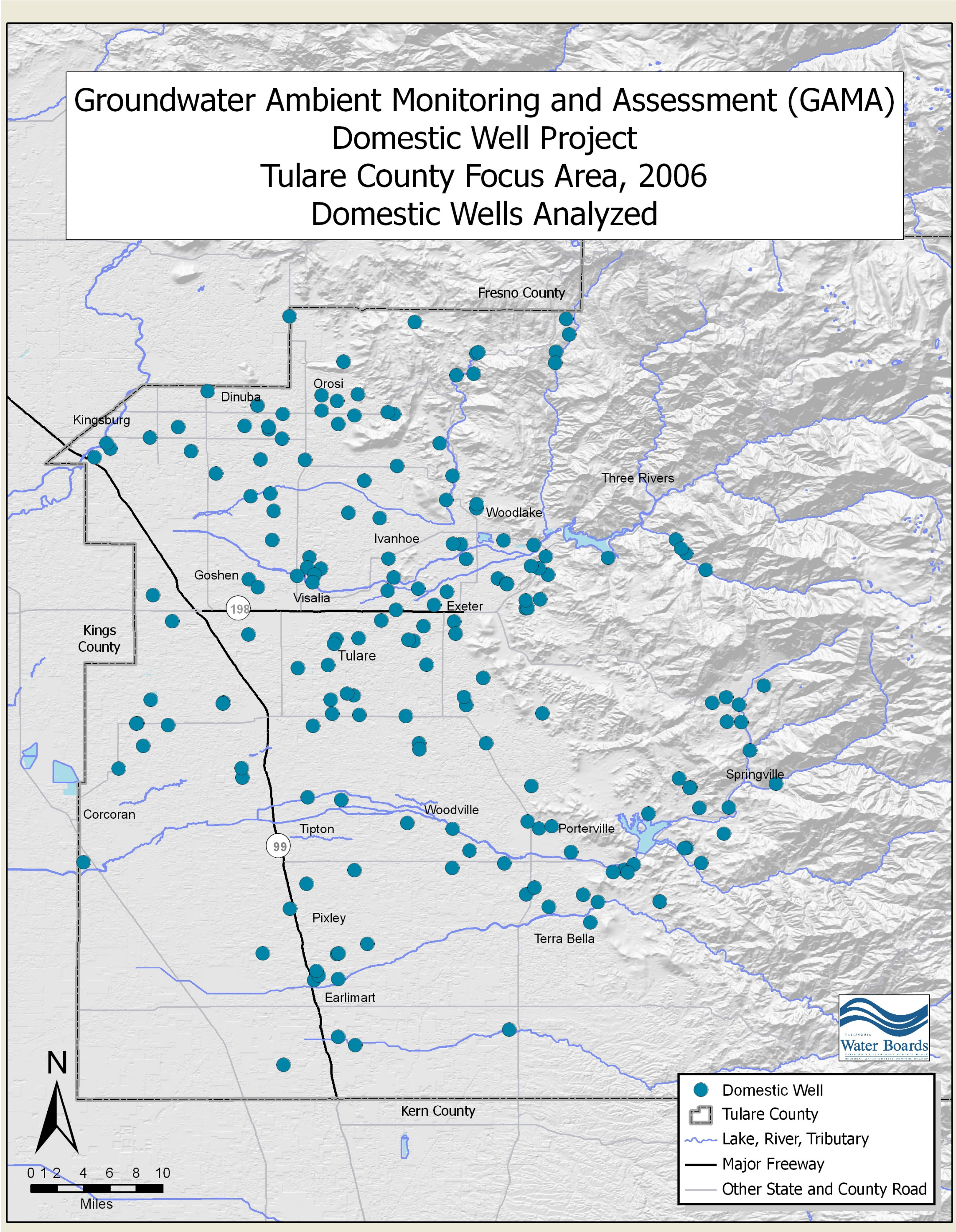
Domestic Well Project Overview

Domestic wells differ from public drinking water supply wells in several respects; domestic wells are generally shallower, are privately owned, supply a single household, and tend to be located in more rural settings where public water supply systems are not available. Census data indicate that there are over 600,000 private domestic wells in California, supplying water to approximately 1.6 million Californians. Tulare County has more than 20,000 domestic wells alone. Due to low pumping rates, the volume of groundwater use by domestic well owners is estimated at 2 percent of the total groundwater volume used in California. The State of California does not regulate water quality in private domestic wells. As a result, many well owners do not have an accurate assessment of their own well water quality.

Domestic well owners are responsible for ensuring the water quality of their domestic well. Domestic wells typically produce very high quality drinking water. However, poor well construction or placement close to a potential source of contamination can result in poor domestic well water quality. Chemicals from surface-related activities such as industrial spills, leaking underground fuel tanks, and agricultural applications can impact groundwater. Biological pathogens from sewers, septic systems, and animal facilities can infiltrate into groundwater. Naturally-occurring chemicals can also contaminate groundwater supplies.

Water quality testing results from the Domestic Well Project are compared to existing groundwater information and public supply well data to help assess California groundwater quality and to better identify issues that may impact private domestic well water.

Figure 1: Location of Sampled Domestic Wells



TULARE COUNTY BACKGROUND

Tulare County is part of one of the nation's most productive agricultural regions. The major economic activity in the county is agriculture, and agricultural output from Tulare County alone accounts for approximately 35% of the state's total agricultural economy. With over $3.5 billion in annual agricultural revenues, Tulare County is the most productive county in the United States in terms of revenue. Tulare has been the number one milk-producing county in the United States since 2003.

HYDROGEOLOGIC SETTING

The western half of Tulare County is comprised of flat valley lands of the southern San Joaquin Valley, while rolling foothills associated with the Sierra Nevada Mountains characterize its eastern half. Topography consists of flat valley land, gently rolling foothills, and canyons of the Sierra Nevada Mountains. Water bearing units within Tulare County include younger and older alluvium, flood-basin deposits, lacustrine, marsh and continental deposits. The older alluvium is moderately to highly permeable and is the major aquifer for Tulare County. Regional groundwater flow is generally southwestward; however, pumping can affect local groundwater flow direction.

Tulare County is located within the San Joaquin Valley Groundwater Basin. The California Department of Water Resources (DWR) Bulletin 118 identifies several groundwater subbasins in Tulare County, including the following:

- **<u>Kings Subbasin</u>**: The Kings Subbasin underlies northern Tulare County west of the Sierra foothills. The groundwater system consists of unconsolidated deposits of alluvium, lacustrine sediments, and flood plain deposits. Approximately 17% of the sampled wells were located in the Kings Subbasin.

- **<u>Kaweah Subbasin</u>**: The Kaweah Subbasin underlies central Tulare County west of the Sierra foothills. The major water-bearing units are made up of unconsolidated Pliocene, Pleistocene, and Holocene-age sediments. Continental lacustrine and marsh deposits are found in the western portion of the subbasin, closer to the Tulare Lake bed. Clay beds associated with lacustrine deposits form aquitards that influence the horizontal movement of local groundwater. The most well-known clay bed is the Corcoran clay, which underlies the western half of the Kaweah Subbasin from 200 to 500 feet below ground surface (bgs). Paleosols or similar oxidized deposits outcrop in the eastern parts of the subbasin closer to the Sierra foothills. The county's population centers of Visalia and Tulare are located within the Kaweah Subbasin. Approximately 44% of the sampled wells were located in the Kaweah Subbasin.

- **Tule Subbasin**: The Tule Subbasin underlies southern Tulare County west of the Sierra foothills. Water bearing deposits in the Tulare Subbasin are comprised of flood-basin deposits, alluvium, the Tulare Formation, and undifferentiated continental sediments deposited during the Pliocene to Holocene. The Tulare Formation contains the Corcoran Clay, which is the major confining unit in the subbasin. Approximately 20% of the sampled wells were located in the Tule Subbasin.

- **Foothills**: The Foothills area is not a DWR-defined basin. It is comprised of wells located east of the valley portion of Tulare County in the higher-elevation. The water bearing unit is generally fractured crystalline rock associated with uplift and emplacement of the Sierra Nevada Mountains. Approximately 19% of the sampled wells were located in the foothills.

In Tulare County, municipal and irrigation wells are typically completed to a total depth of 100 to 500 feet bgs, except for within the Tule Subbasin where well depths range between 200 to 1,400 feet bgs (DWR, 2004). Groundwater recharge in the county occurs through river and stream seepage, percolation of irrigation water, canal seepage, and intentional recharge. Land subsidence of up to 16 feet occurred due to deep compaction of fine-grained units. This subsidence is thought to be due to groundwater withdrawal.

Well Construction Data

The completed depths of wells sampled in Tulare County as part of the Domestic Well Project are shown in Table 1 (well construction data was available for 141 of the 181 sampled wells). The data suggest that the shallow aquifer system provides adequate water supply for domestic use. Over 50% of the wells sampled as part of the Domestic Well Project were completed at a depth less than 200 feet.

Table 1: Domestic Well Depths

GAMA Domestic Well Project, Tulare County Focus Area

Total Well Depth (feet bgs)	Number of Wells
0-24	1
25-49	1
50-74	8
75-99	19
100-124	9
125-149	18
150-174	14
175-199	13
200-224	5
225-249	8
250-274	7
275-299	9
300-324	11
325-349	0
350-374	1
375-400	4
>400	12

Note: Well depth data not available for all wells

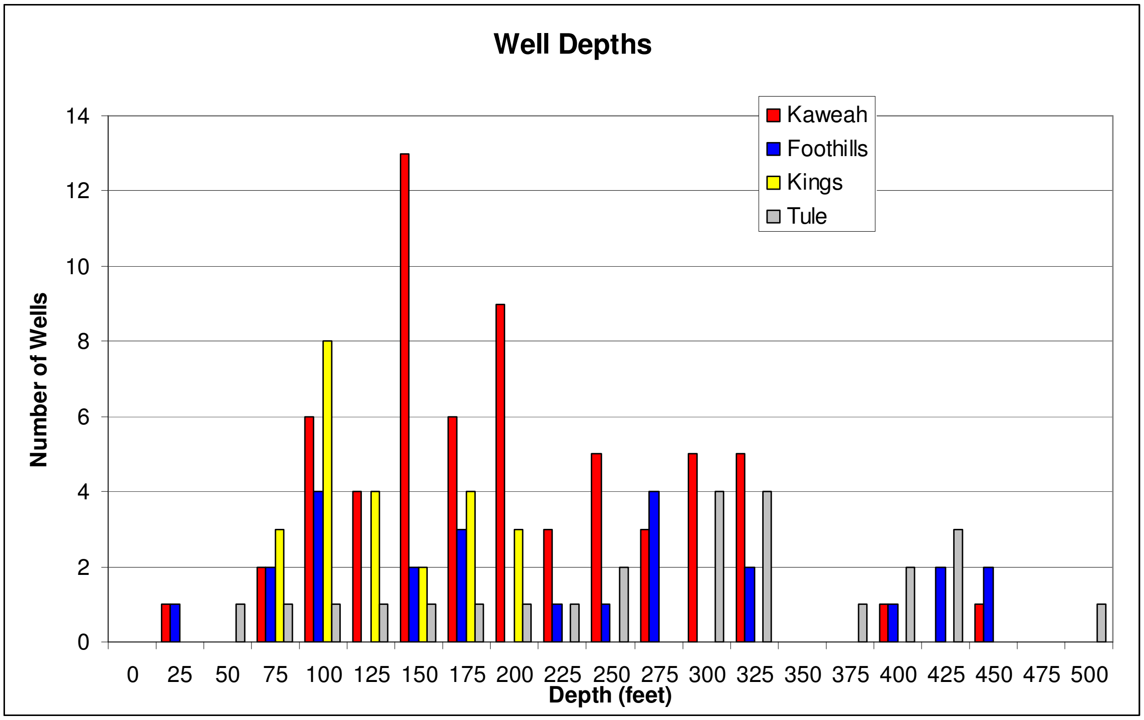


Figure 2: Well Depth Histogram by Subbasin

The depths of wells sampled as part of the Domestic Well Project were grouped by subbasin.

- Wells sampled in the Kaweah Subbasin are generally completed to depths between 100 and 250 feet bgs. However, a significant number of wells in the Kaweah Subbasin are completed at depths greater than 250 feet bgs.

- Wells sampled in the Kings Subbasin are generally completed at shallower depths – all sampled wells are less than 200 feet bgs.

- Wells sampled in the Tule Subbasin are in general deeper than wells drilled in other parts of the county. Approximately 68% of wells sampled in the Tule Subbasin are completed to depths greater than 250 feet bgs, suggesting that either depth to groundwater is greater or that domestic well owners are avoiding shallower groundwater in this subbasin.

- There is no discernable pattern observed in wells sampled in the Foothills area, where both very shallow and very deep wells are observed.

METHODS

Well Selection

Tulare County was selected by GAMA due to the large number of domestic wells within the county and the availability of electronic well owner data. Based on a 1999 survey by the State of California, Department of Finance census, over 20,000 private domestic wells are located in Tulare County. Tulare County is the eighth largest user of domestic well water in California, based upon volume of withdrawls (Figure 3).

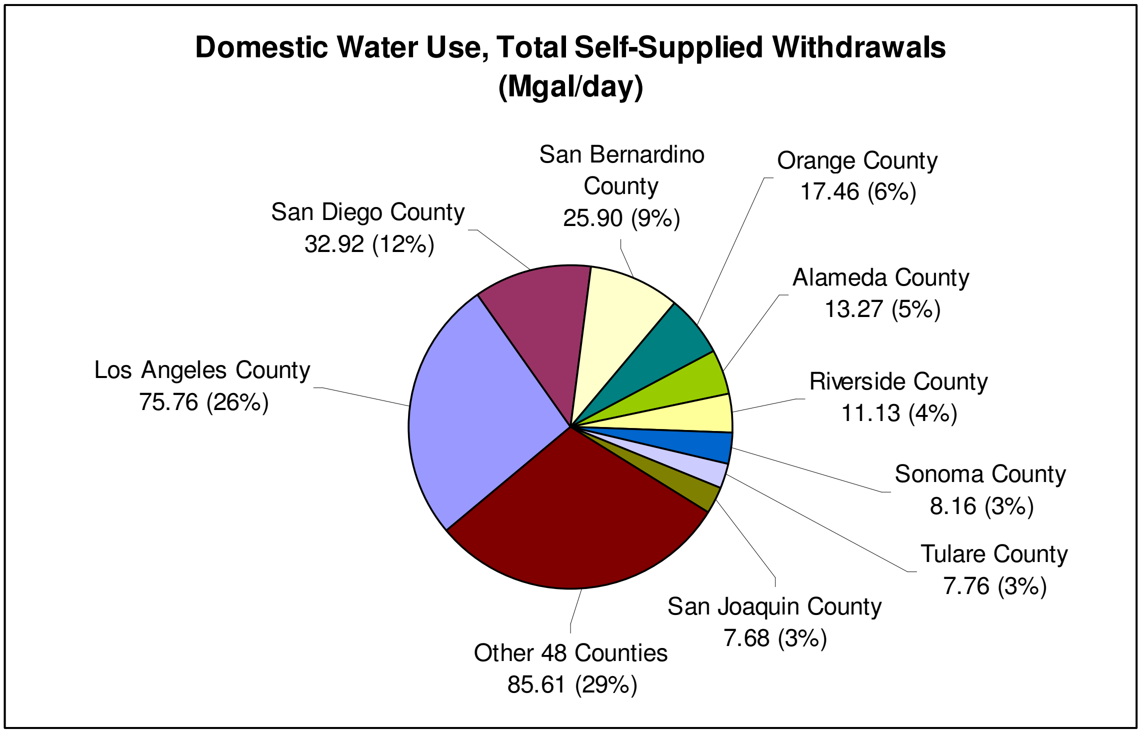


Figure 3: Top 10 California Counties, Volume of Domestic Water Use

(USGS, 2000)

The Tulare County Department of Health and Human Services provided GAMA staff with an electronic database containing the names, mailing addresses, and parcel map book numbers of domestic well owners. Approximately 1,500 of these domestic well owners were mailed a brochure in Spanish and English containing information about the GAMA well testing program and inviting them to participate. A total of 181 domestic well owners volunteered to have their well tested.

Sample and Data Collection

Well construction information was obtained from either well owners or well completion reports (well logs). Observations at each well noted the location of nearby septic systems, large-scale agriculture, or livestock enclosures that could result in contamination of the well. Well locations were recorded using a Geographic Positioning Satellite (GPS) unit. Water temperature, pH, and specific electrical conductance were measured and documented in the field.

Groundwater samples were collected as close to the well head as possible. Most often the sample was collected from a faucet or spigot just before or after the pressure tank. New nitrile gloves were worn by field staff during sample collection to minimize contamination during sampling. Samples were collected in laboratory supplied pre-cleaned bottles, and were stored in an iced cooler until delivery to the lab within 24 hours.

Trip blank and duplicate samples were collected at approximately 10 percent of the well locations. These samples are collected and analyzed to help determine if cross contamination was introduced during sample collection, processing, storage, and/or transportation. All trip blank and duplicate data results were within acceptable range criteria.

Sample Analysis

Groundwater samples were analyzed by Delta Environmental Laboratories in Benicia, California for the following:

- Bacteria (total and fecal coliform)
- Inorganic parameters (metals, major anions and general minerals)
- Volatile organic compounds (VOCs)
- Non-routine analytes: radionuclides, pesticides, perchlorate

In addition, selected groundwater samples were analyzed by LLNL for the following:

- Stable isotopes of oxygen and hydrogen in water
- Stable isotopes of nitrogen and oxygen in nitrate

Stable isotope results are pending, and will be summarized in a separate report.

RESULTS

<u>Detections Above a Drinking Water Standard</u>

There are no Federal or State water quality standards that regulate private domestic well water quality. The Domestic Well Project has compared the test results to the following public drinking water standards: CDPH primary maximum contaminant levels (MCLs), secondary MCLs (SMCLs), and notification levels (NLs). The MCL is the highest concentration of a contaminant allowed in public drinking water. Primary MCLs address health concerns, while secondary MCLs (SMCLs) address aesthetics, such as taste and odor. NLs are health-based advisory levels for chemicals in public drinking water that have no formal regulatory standards.

Analytes that were detected in one or more wells above a drinking water standard:

- Total and Fecal Coliform Bacteria
- Nitrate (NO_3^-)
- Nitrite
- 1,2-Dibromo-3-Chloropropane (DBCP)
- 1,2,3-Trichloropropane
- Gross alpha activity
- Radium 226+228
- Uranium
- Perchlorate
- Arsenic
- Beryllium
- Boron
- Chromium
- Thallium
- Nickel
- Iron
- Aluminum
- Manganese
- Vanadium
- Zinc
- Total Dissolved Solids (TDS)

A summary of all analytes detected above a drinking water standard is outlined in Table 2. Detailed results of the domestic well sampling are summarized below.

Table 2: Summary of Detections Above a Drinking Water Standard

GAMA Domestic Well Project, Tulare County Focus Area, Concentrations Above Public Drinking Water Standards

Total Number of Wells Sampled: 181

Compound	Wells Above a Public Drinking Water Standard		Range of Detected Values Above Public Drinking Water Standards	Public Drinking Water Standards[3]		
	Number	Percentage		MCL	SMCL	NL
Major Ions & General Chemistry						
Nitrate (as N)	72	40%	10.1 - 54 mg/L	10 mg/L		
Perchlorate	2 (of 30 sampled)	6%	7.9 - 13 µg/L	6 µg/L		
Nitrite (as N)	4	2%	1.52 - 4.08 mg/L	10 mg/L		
Total Diss. Solids (TDS)	4	2%	1,002 - 1,052 mg/L		1,000 mg/L	
Metals						
Vanadium	14	8%	50.1 - 42.9 µg/L			50 µg/L
Aluminum	2	1%	275 - 450 µg/L		200 µg/L	
Arsenic	2	2%	10.4 - 14 µg/L	10 µg/L		
Beryllium	1	<1%	113 µg/L	4 µg/L		
Boron	1	<1%	48.4 mg/L			1 mg/L
Chromium	2	1%	76.7 - 91.9 µg/L	50 µg/L		
Iron	2	1%	608 - 650 µg/L		300 µg/L	
Manganese	2	1%	93.5 - 172 µg/L		50 µg/L	
Nickel	3	2%	121 - 213 µg/L	100 µg/L		
Thallium	6	3%	2.11 - 7.32 µg/L	2 µgL		
Zinc	1	<1%	17.3 mg/L		5 mg/L	
Radionuclides						
Gross Alpha	3 (of 13 sampled)	23%	15.1 - 602 pCi/L	15 pCi/L[1]		
Radium 226+228	1 (of 13 sampled)	8%	5.1 pCi/L	5 pCI/L[1]		
Uranium	1 (of 13 sampled)	8%	228 pCi/L	20 pCi/L[1]		
Bacteria Indicators						
Total Coliform	60	33%	NA[2]	Present		
Fecal Coliform	13	7%	NA[2]	Present		
Organic Compounds (Pesticides and VOCs)						
1,2-dibromo 3-chloropropane (DBCP)	8	4%	0.221 - 2.83 µg/L	0.2 µg/L		
1,2,3-trichloropropane	1	<1%	0.8			0.005 µg/L

Notes:

1. pCi/L = picocuries per liter; mg/L = milligrams per liter, or parts per million (ppm); µg/L = micrograms per liter or parts per billion (ppb)
2. Coliform are evaluated on a presence/absence criteria. No range can be determined
3. MCL = California Department of Public Health (CDPH) Primary Maximum Contaminant Level; SMCL = CDPH Secondary Maximum Contaminant Level;

NL = CDPH Notification Level

Coliform Bacteria

Total coliform bacteria were detected in 60 wells (33% of total samples). Thirteen of the wells with positive total coliform detections also tested positive for fecal coliform (7% of sampled wells). Figure 4 shows the distribution of total and fecal coliform bacteria detected in sampled domestic wells.

General Minerals

General minerals detected in domestic well samples are summarized in Table 3. General minerals include measures of alkalinity, hardness, and total dissolved solids (TDS). All of the general minerals listed in Table 3, with the exception of foaming agents (MBAS), naturally occur in groundwater. However, human activities can sometimes change the concentrations of these minerals in groundwater.

There are no established regulatory levels for many general mineral analytes; only foaming agents (MBAS), EC, and TDS have SMCLs. MBAS, which are typically associated with the presence of detergents, were not detected at a concentration above the MCL. TDS, which is an estimate of the total concentration of all non-settleable (dissolved) components in water, was detected at concentrations above the SMCL (1,000 mg/L) in four wells.

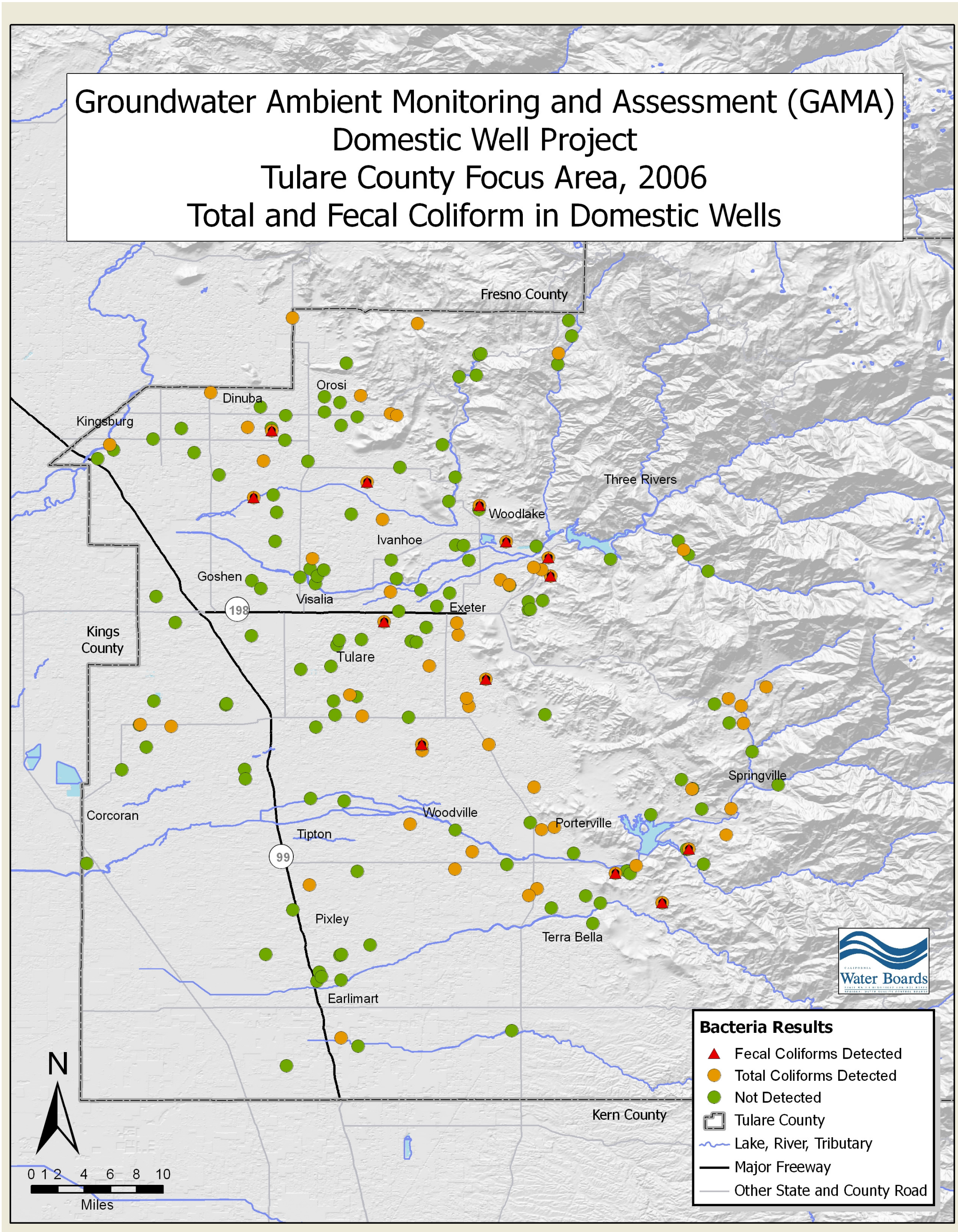
Table 3: General Minerals

GAMA Domestic Well Project, Tulare County Focus Area

Analyte	Range of Detected Values (mg/L)	Public Drinking Water Standard (mg/L)	Number of Wells Above Standard
Total Alkalinity (as $CaCO_3$)	34 - 660	NA	0
Bicarbonate	41 - 805	NA	0
Carbonate	122	NA	0
Calcium	7.92 - 169	NA	0
Magnesium	0.42 - 93.3	NA	0
Potassium	0.35 - 14.1	NA	0
Sodium	230 - 296	NA	0
Foaming Agents (MBAS)	0.06 - 0.07	0.5 (SMCL)	0
Hardness (Total) as $CaCO_3$	19.8 - 608	NA	0
pH, Laboratory	5.48 - 8.39	NA	0
Total Dissolved Solids (TDS)	5.52 – 1,052	1,000 (SMCL)	4

Notes:
1. SMCL = Secondary Maximum Contaminant Level
2. mg/L = milligrams per liter
3. NA = Health or aesthetic standards are not available for this constituent

Figure 4: Total and Fecal Coliform Results



Major Anions

Major anions detected in domestic well samples are summarized in Table 4. Nitrate (NO_3^-), nitrite (NO_2), and perchlorate were detected at concentrations above a drinking water standard. Nitrate was measured as mg/L as N. Nitrate was detected in 173 wells at concentrations ranging from 0.11 to 54 mg/L (as N). Nitrate was detected above the MCL (10 mg/L as N) in 72 wells. The distribution of nitrate in domestic wells is shown on Figure 5. Nitrite was detected in 68 wells, and was detected at concentrations above the MCL (1.0 mg/L) in four wells. Perchlorate was sampled in a smaller subset of wells (30 wells), and was detected above the MCL (0.006 mg/L) in two wells.

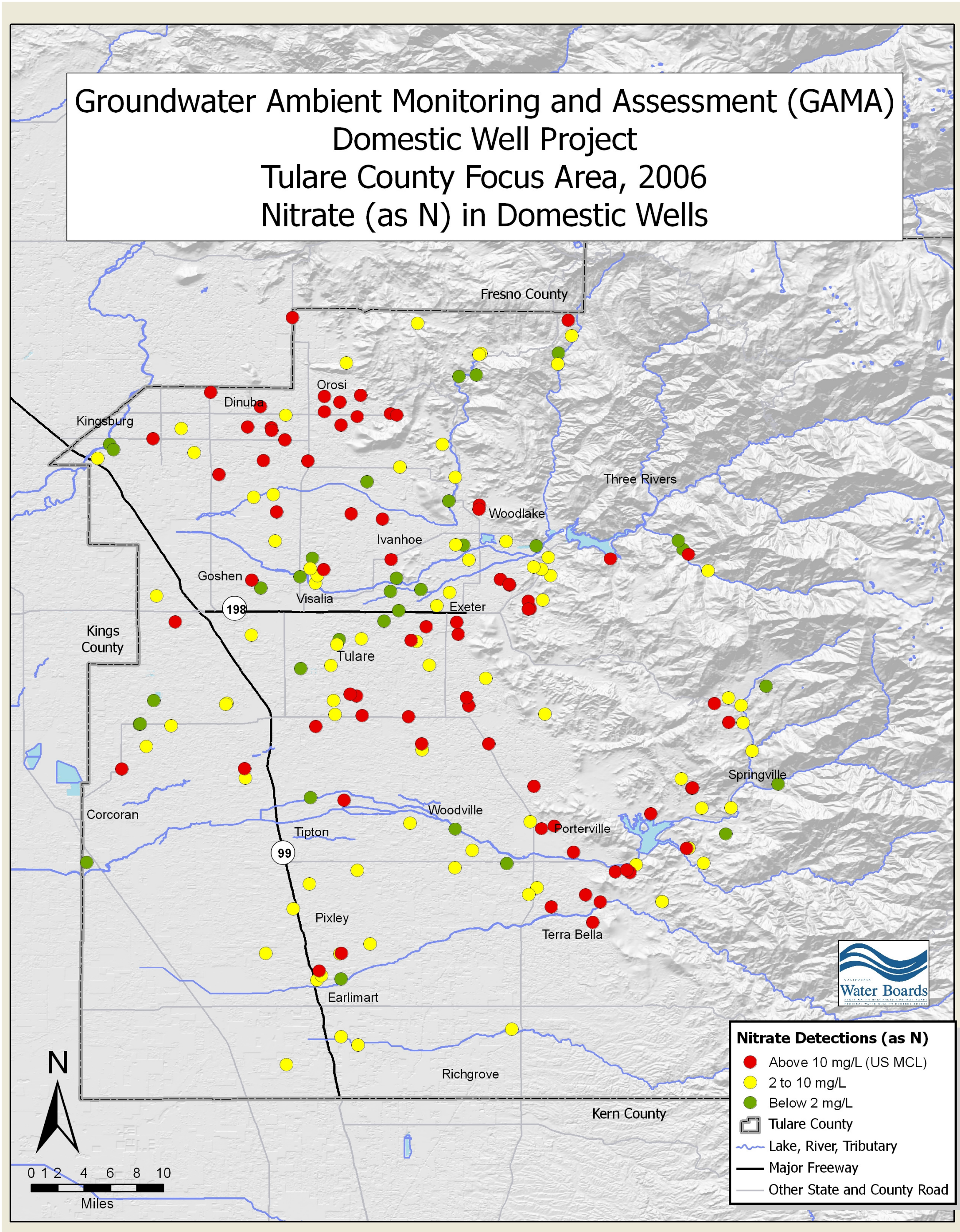
Table 4: Major Anions

GAMA Domestic Well Project, Tulare County Focus Area

Analyte	Range of Detected Values (mg/L)	Public Drinking Water Standard (mg/L)	Number of Wells Above Standard
Chloride	1.1 - 341	500 SMCL	0
Fluoride	0.1- 0.7	2 MCL	0
Nitrate (as N)	0.11 - 54	10 MCL	72
Nitrite (as N)	0.1 - 4.1	1 MCL	4
Perchlorate	0.6 - 13	0.006 MCL	2
Sulfate	2.4 - 220	500 SMCL	0

Notes: MCL = Maximum Contaminant Level, SMCL = Secondary Maximum Contaminant Level. mg/L = milligrams per liter

Figure 5: Nitrate (as N) Results



Metals

Metals detected in domestic well samples are shown in Table 5. Eleven metals (aluminum, arsenic, beryllium, boron, chromium, iron, manganese, nickel, thallium, vanadium, and zinc) were detected at concentrations above a public drinking water standard. A summary of metals detected above a drinking water standard is provided below. The locations of wells with detections of vanadium and thallium above a drinking water standard are shown in Figures 6 and 7, respectively.

- Aluminum was detected in 120 wells at concentrations ranging from 5.85 to 450 µg/L. Aluminum was detected above the SMCL (200 µg/L) in two wells.

- Arsenic was detected in 126 wells at concentrations ranging from 0.1 to 14 µg/L. Arsenic was detected above the MCL (10 µg/L) in two wells.

- Beryllium was detected in one sample at 113 µg/L. This concentration is above the MCL of 4 µg/L.

- Boron was detected in 161 wells at concentrations ranging from 7.8 to 48,400 µg/L. Boron was detected above the NL (1,000 µg/L) in one well.

- Total chromium was detected in 42 wells at concentrations ranging from 2.36 to 91.9 µg/L. Chromium was detected above the MCL (50 µg/L) in two wells.

- Manganese was detected in 149 wells at concentrations ranging from 0.11 to 172 µg/L. Manganese was detected above the SMCL (50 µg/L) in two wells.

- Iron was detected in 44 wells at concentrations ranging from 20.1 to 650 µg/L. Iron was detected above the SMCL (300 µg/L) in two wells.

- Nickel was detected in 55 wells at concentrations ranging from 2.16 to 213 µg/L. Nickel was detected above the MCL (100 µg/L) in three wells.

- Thallium was detected in 25 wells at concentrations ranging from 0.2 to 7.32 µg/L. Thallium was detected above the MCL (2 µg/L) in six wells.

- Vanadium was detected in 165 wells at concentrations ranging from 3.77 to 92.9 µg/L. Vanadium was detected above the NL (50 µg/L) in 14 wells.

- Zinc was detected in 171 wells at concentrations ranging from 1.37 to 17,300 µg/L. Zinc was detected above the SMCL (5 mg/L) in one sample.

Table 5: Metals

GAMA Domestic Well Project, Tulare County Focus Area

Analyte	Range of Detected Values (µg/L)	Public Drinking Water Standard (µg/L)	Number of Wells Above Standard
Aluminum	5.85 - 450	200 SMCL	2
Arsenic	0.1 - 14	10 MCL	2
Barium	1.54 - 495	1,000 MCL	0
Beryllium	113	4 MCL	1
Boron	7.8 – 48,400	1,000 NL	1
Cadmium	1.16	5 MCL	0
Chromium (Total)	0 - 91.9	50 MCL	2
Copper	1.1 - 60.6	1,000 SMCL	0
Iron	20.1 - 650	300 SMCL	2
Lead	0.11 - 6.48	15 NL	0
Manganese	0.11 - 172	50 SMCL	2
Nickel	3.16 - 213	100 MCL	3
Selenium	0.11 - 1.55	50 MCL	0
Silver	33.6	100 SMCL	0
Thallium	0.2 - 7.32	2 MCL	6
Vanadium	0.2 92.9	50 NL	14
Zinc	1.37 - 17,300	5,000 SMCL	1

Notes:

1. MCL = Maximum Contaminant Level, SMCL = Secondary Maximum Contaminant Level, NL = Notification level
2. µg/L = micrograms per liter

Figure 6: Vanadium Results

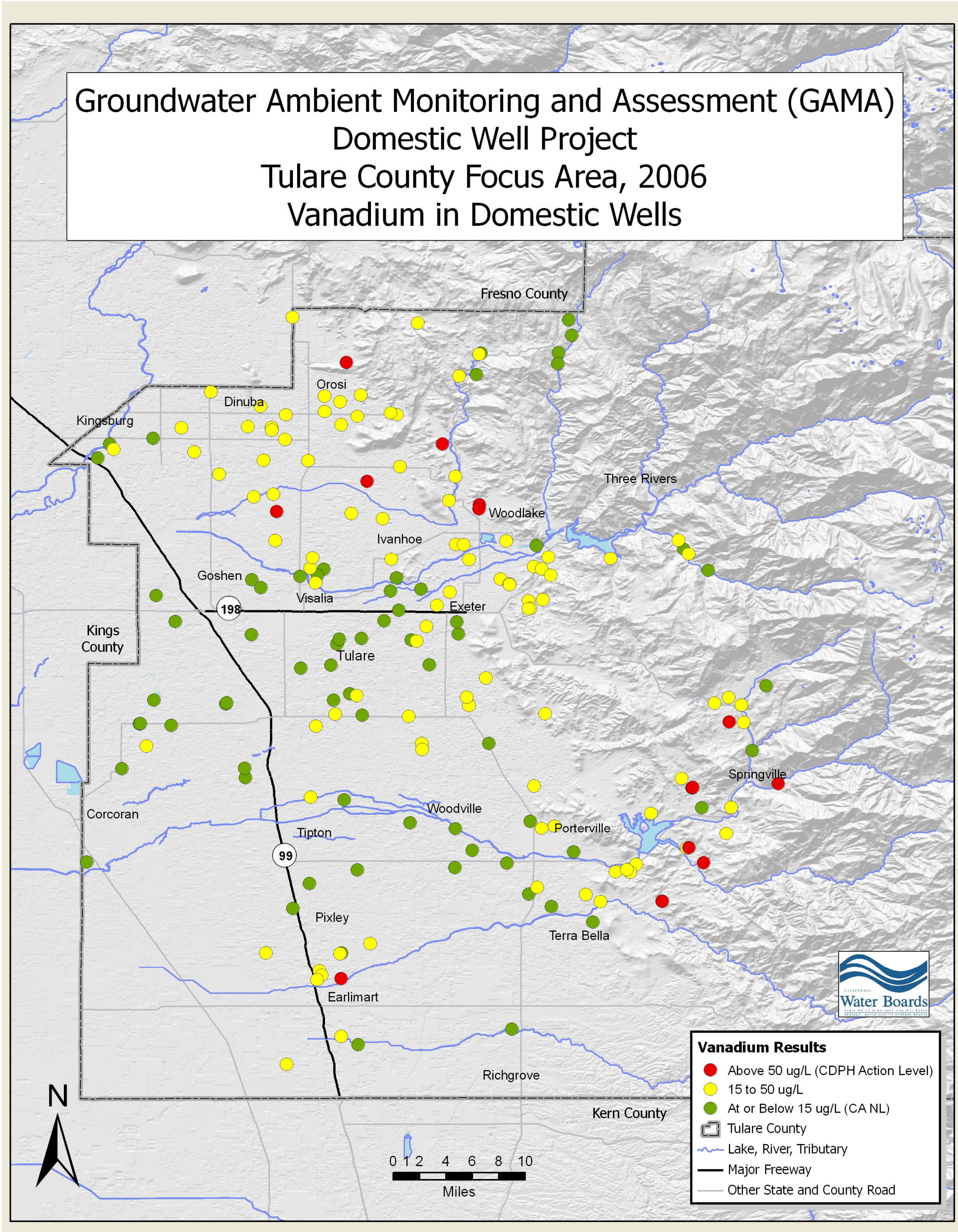
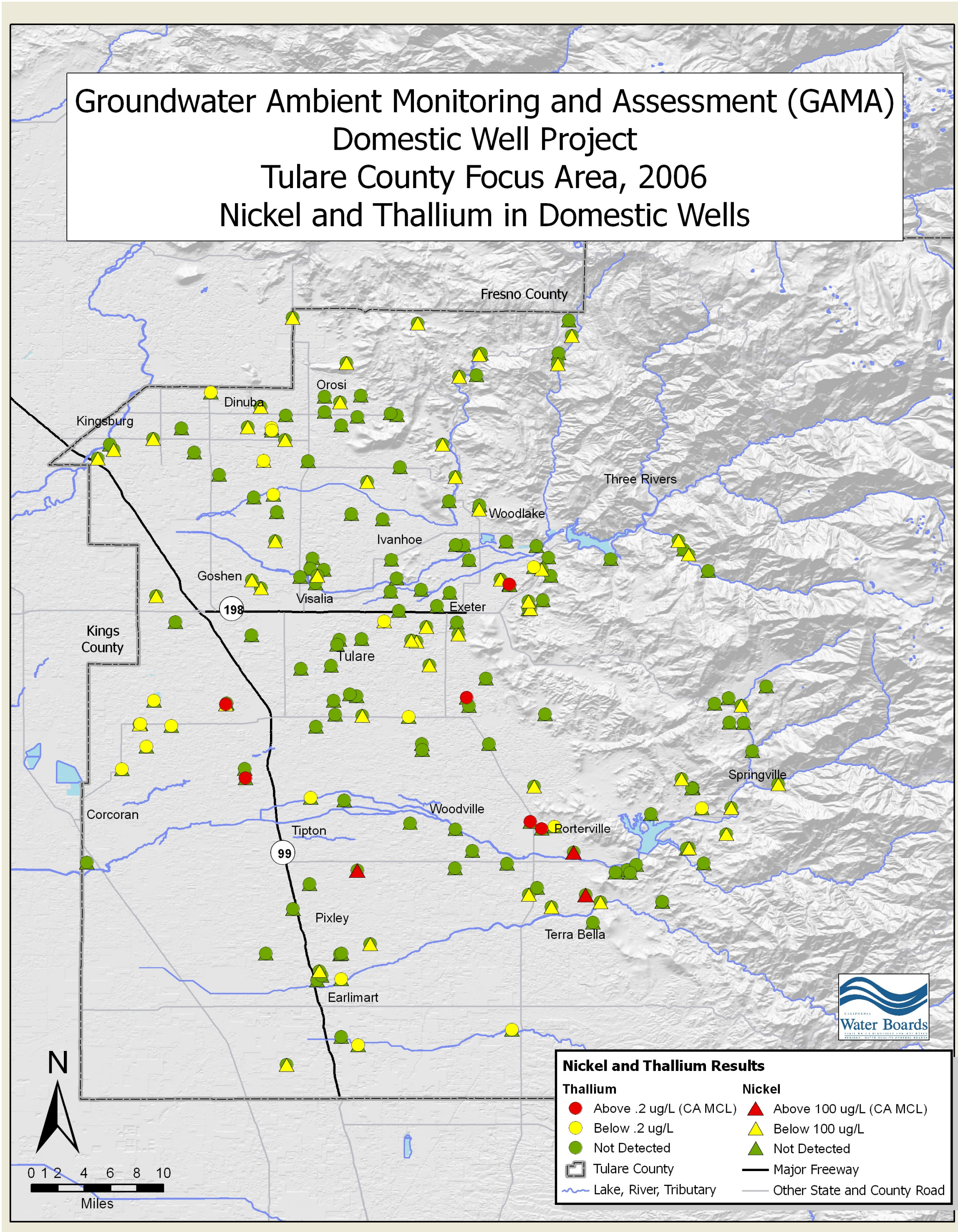


Figure 7: Thallium and Nickel Results



Radionuclides

Thirteen domestic wells were selected for radionuclide analyses. Test results are shown in Table 6. Radionuclide analyses included gross alpha particle activity, gross beta particle activity, combined radium (the activity of radium-226 and radium-228), tritium, and uranium. Drinking water standards for radionuclides are in picocuries per liter (pCi/L) or millirems per year (millirem/yr). A curie is the radioactivity associated with one gram of radium – a picocurie is one trillionth of a curie. The gross beta activity drinking water standard is in terms of millirems per year. A 'rem' is a unit of measure describing how a specific type of radiation damages biologic tissue. A millirem is one thousandth of a rem. There is no simple conversion between a curie and a rem. Gross beta activity previously had an MCL of 50 pCi/L, which was replaced by the 4 millirem/yr standard. Gross beta activity of 50 pCi/L is still used as a trigger for additional testing by CDPH. A summary of radionuclide test results is included below. The locations of wells sampled for uranium, gross alpha activity, and radium (226+228) is shown in Figure 8.

- Gross alpha activity was detected in all thirteen sampled wells at activities ranging from 2.8 to 602 pCi/L. Gross alpha activity was above the MCL (15 pCi/L) in three wells.

- Gross beta activity was detected in twelve of the thirteen sampled wells, with activities ranging from ranging from 2.8 to 7.15 pCi/L. None of the gross beta activities were above the MCL (4 milirem/year) or NL (50 pCi/L).

- Combined radium (radium 226+228) activity was detected in nine of thirteen wells at activities ranging from 0.71 to 5.2 pCi/L. Radium activity was above the MCL (5 pCi/L) in one sample.

- Tritium activity was detected in ten of thirteen sampled wells at activities ranging from 181 to 1,264 pCi/L. None of the wells were above the MCL (20,000 pCi/L).

- Uranium activity was detected in all thirteen sampled wells at activities ranging from 2.15 to 228 pCi/L. Uranium activity was above the MCL (20 pCi/L) in one sample.

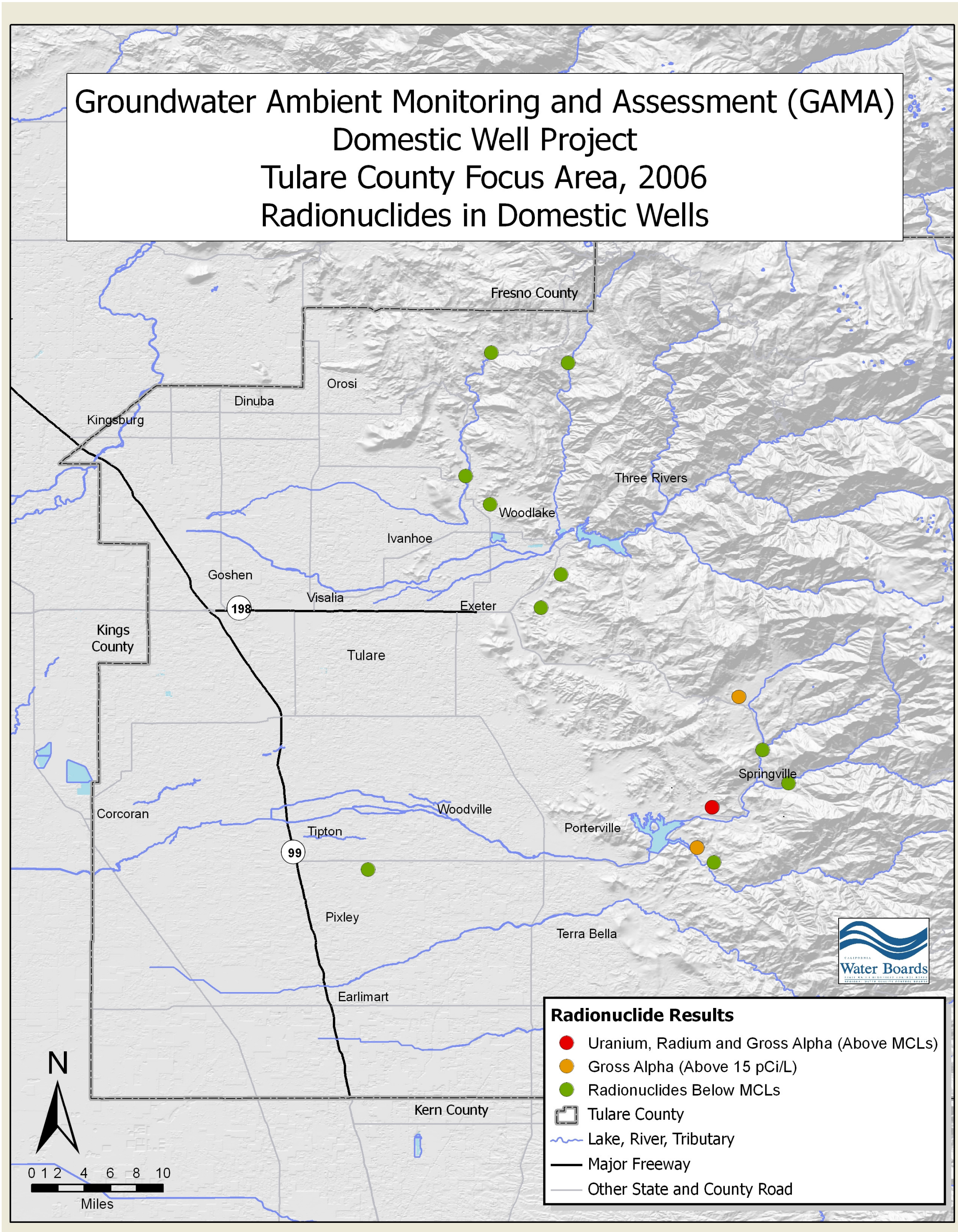
Table 6: Radionuclides

GAMA Domestic Well Project, Tulare County Focus Area

Analyte	Range of Detected Values (pCi/L)	Public Drinking Water Standard (pCi/L)	Number of Wells Above Standard
Gross alpha	2.8 - 602	15 MCL	3
Gross beta	2.8 - 7.15	50 NL 4 milirem/yr MCL	0
Radium 226+228	0.71 - 5.2	5 MCL	1
Tritium	181 – 1,264	20,000 MCL	0
Uranium	2.15 - 228	20 MCL	1

Notes: MCL = Maximum Contaminant Level. pCi/L = picocurie per liter. milirem/yr = milirems per year

Figure 8: Radionuclides (Gross Alpha, Radium 226+228, and Uranium)



Pesticides

Tulare County is an important agricultural county. Pesticides are used to maintain high production and prevent crop-loss. Only pesticides with high historical or modern use and potential for reaching groundwater were tested.

Historically, 1,2-dibromo-3-chloropropane (DBCP) has been detected in groundwater in the San Joaquin Valley at concentrations greater than the MCL. DBCP was tested in all Domestic Well Project samples. The locations of wells with detections of DBCP are shown in Figure 9. Twenty selected domestic wells were tested for an additional suite of pesticides or pesticide-degradates: diuron, atrazine, chlorotraizine (DACT), deisopropylatrazine (DIA), deethylatrazine (DEA), prometon, simazine, metribuzin, prometryn, bromacil, cyanazine, norflurazon, hexazinone, desmethylnorflurazon, primidone, and metolachlor. LLNL performed the analyses for all pesticides other than DBCP, following California Department of Food and Agriculture (CDFA) methodology. Technological capabilities at LLNL allow low detection limits for target chemicals. Test results from LLNL are reported at parts per trillion (ppt, or ng/L) concentrations. The locations of wells with detections of any pesticide are shown in Figure 10.

Prometon, metribuzin, and prometryn were not detected in any of the wells selected for pesticide testing. All pesticides, with the exception of DBCP, were detected at concentrations less than established drinking water standards. Other pesticide compounds were detected as follows:

- DBCP was detected in 27 wells at concentrations ranging from 0.01 to 1.63 µg/L. Concentrations of DBCP were above the MCL of 0.2 µg/L in eight wells.

- Hexazinone was detected in one sample at a concentration of 0.027 µg/L.

- Primidone was detected in one sample at a concentration of 0.070 µg/L.

- Metolachlor was detected in one sample at a concentration of 0.077 µg/L.

- Cyanazine was detected in two samples, both at concentrations of 0.012 µg/L.

- Atrazine was detected in three wells at concentrations ranging from 0.012 to 0.037 µg/L.

- DIA was detected in eleven wells at concentrations ranging from 0.016 to 0.732 µg/L.

- DACT was detected in five wells at concentrations ranging from 0.031 to 0.099 µg/L.

- DEA was detected in six wells at concentrations ranging from 0.012 to 0.050 µg/L.

- Diuron was detected in nine wells at concentrations ranging from 0.011 to 0.750 µg/L.

- Simazine was detected in ten wells with concentrations ranging from 0.011 to 0.158 µg/L.

- Bromacil was detected in eight wells at concentrations ranging from 0.016 to 1.021 µg/L.

- Norflurazon was detected in five wells at concentrations ranging from 0.022 to 1.390 µg/L.

- Desmethylnorflurazon (a degradate of norflurazon) was detected in four wells at concentrations ranging from 0.093 to 0.323 ug/L.

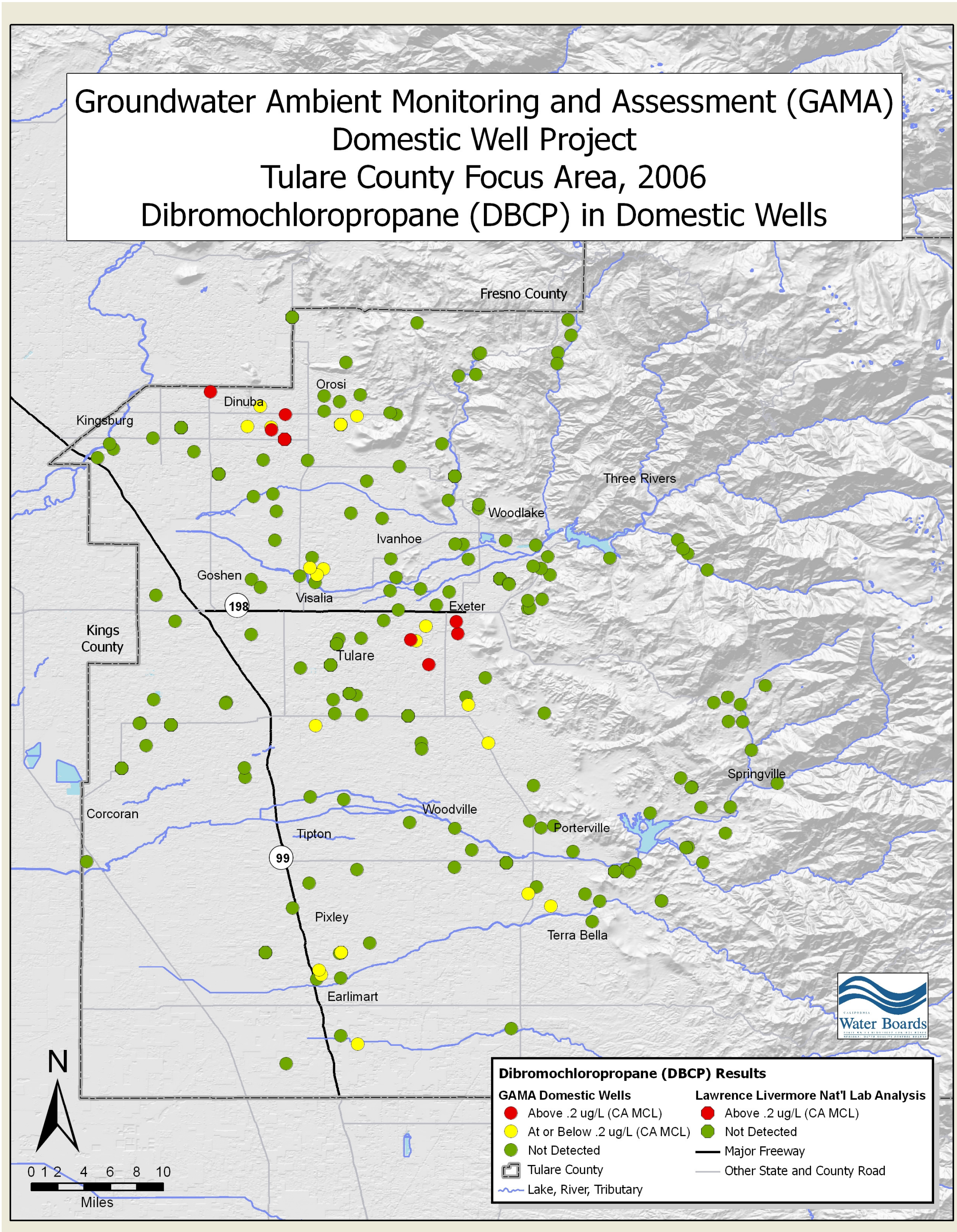
Table 7: Pesticides

GAMA Domestic Well Project, Tulare County Focus Area

Analyte	Range of Detected Values (µg/L)	Public Drinking Water Standard (µg/L)	Number of Wells Above Standard
DBCP	0.01 - 1.63	0.2 MCL	8
Diuron	0.011 - 0.750	NA	0
DACT	0.031 - 0.099	NA	0
DIA	0.016 - 0.732	NA	0
DEA	0.012 - 0.050	NA	0
Prometon	Not Detected	NA	0
Simazine	0.011 - 0.158	4 MCL	0
Atrazine	0.012 - 0.037	1 MCL	0
Metribuzin	Not Detected	NA	0
Prometryn	Not Detected	NA	0
Bromacil	0.016 - 1.021	NA	0
Cyanazine	0.012	NA	0
Hexazinone	0.027	NA	0
Primidone	0.070	NA	0
Metolachlor	0.077	NA	0
Norflurazon	0.022 - 1.390	NA	0
Desmethylnorflurazon	0.093 - 0.323	NA	0

Notes: NA = Not Available; Public Drinking Water Standards are not available for all chemicals. MCL = Maximum Contaminant Level . µg/L = micrograms per liter

Figure 9: DBCP Results



Volatile Organic Compounds (VOCs)

VOCs detected in domestic wells are summarized in Table 8. A single VOC was detected above a public drinking water standard (NL) in wells sampled as part of the Domestic Well Project. Low-level concentrations, below public drinking water standards, of six additional VOCs were detected.

- 1,1-Dichloroethane at a concentration of 0.6 µg/L in one well
- 1,2,3-Trichloropropane at a concentration of 0.8 µg/L in one well. This concentration is above the NL (0.005 µg/L).
- Chloroform at concentrations ranging from 0.7 to 15.8 µg/L in five wells
- Chloromethane at a concentration of 1 µg/L in one well
- N-butylbenzene at a concentration of 0.2 µg/L in one well
- Tetrachloroethene (PCE) at a concentration of 2.33 µg/L in one well
- Toluene at a concentration of 22 µg/L in one well

Table 8: VOCs
GAMA Domestic Well Project, Tulare County Focus Area

Analyte	Range of Detected Values (µg/L)	Public Drinking Water Standard (µg/L)	Number of Wells Above Standard
1,1-Dichloroethane	0.6	5 MCL	0
1,2,3-Trichloroproane	0.8	0.005 NL	1
Chloroform	0.7 - 15.8	80 MCL	0
Chloromethane	1.0	NA	0
n-butylbenzene	0.2	260 NL	0
Tetrachloroethene (PCE)	2.33	5 MCL	0
Toluene	22	150 MCL	0

Notes:
1. MCL = Maximum Contaminant Level , NL = Notification Level
2. µg/L = micrograms per liter
3. NA = Public drinking water standards are not available for this constituent

POSSIBLE SOURCES OF CHEMICALS IN GROUNDWATER

Twenty constituents were detected above water quality standards in the Tulare County Focus Area. Five of these constituents were observed in more than five percent of the sampled wells. Potential sources for these constituents, summarized from groundwater collected across the country, are discussed below. The focus of this sampling was not to pinpoint a source of chemicals found in groundwater, and the source descriptions do not imply that a chemical observed in a domestic well comes from any single, specific source. The summaries are provided as information for well owners.

Nitrate

Nitrate is commonly found in groundwater. Low levels of nitrate may be natural in origin; however, high concentrations of nitrate are generally related to fertilizer production and application, septic systems, agricultural and animal waste ponds, leaking sewer lines, sludge or manure application, and the production of explosives. The most significant health threat associated with nitrate is associated with methemoglobinaemia ("blue baby" syndrome). Toxic effects occur when bacteria in an infant's stomach convert nitrate to more toxic nitrite, interfering with the body's ability to carry oxygen. High nitrate levels are also a health risk for pregnant women. Some studies suggest an association between high nitrate in drinking water and certain types of cancers (Weyer et al., 2001).

Coliform Bacteria

Total coliform bacteria are naturally present in the environment, and in general are harmless to people. However, some coliforms may cause illness in humans, and the presence of coliforms is an indication that other micro-organisms may be present. Fecal coliforms are found in human and animal wastes and, when present, indicate contamination. Drinking water that contains coliform bacteria increases the risk of becoming ill. Well owners should not drink water with fecal coliform in it.

Vanadium

Vanadium enters the environment from natural sources and from the burning of fossil fuels. It is generally considered a naturally-occurring element in groundwater although some industrial activities, such as mining, may result in increased groundwater concentrations. The health effects of ingesting high doses of vanadium are relatively unknown. Some animals that have ingested vanadium over a long time have developed minor kidney and liver changes, while ingestion of high levels of vanadium by pregnant animals has resulted in minor birth defects.

Radionuclides

Radionuclides are a naturally occurring part of the Earth, and are present (usually at very low levels) in every substance and material on the planet. Most radiation detected in groundwater is the result of interactions with natural geologic materials that contain trace levels of radioactive elements. Different radionuclides will interact and damage biologic activity differently – as a result, some constituents have greater or lower MCLs than others. Drinking water with concentrations of radionuclides above a public drinking water standard increases the risk of certain types of cancers.

DBCP

DBCP was used as a soil fumigant to control nematodes. Prior to 1979, DBCP was widely applied to over 40 types of crops. In California, DBCP was primarily used on grapes and tomatoes. DBCP was banned in the continental United States in 1979. However, DBCP travels easily in groundwater and may persist in groundwater for long periods of time. In sunlight, DBCP is rapidly degraded and broken down. Data collected on workers involved in the manufacture and formulation of DBCP has shown that DBCP can cause sterility or other reproductive effects at very low levels of exposure. There is some evidence that DBCP may have the potential to cause cancer with lifetime exposure at levels above the MCL.

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